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serve as types for intelligent use by other topographers working in similar glaciated areas.

As proof of the validity of the arguments used by Johnson and Matthes one has only to compare the latter's splendid U. S. Geological Survey maps of glaciated forms in the Rocky Mountains, of stream work and weathering forms in the Grand Canyon of the Colorado, and of similar features in the Yosemite Valley, with poorer maps by other topographers who do not know the geology and physiography of what they map.

REGIONAL POPULATION GROUPS OF ATACAMA,* PART I.

BY

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INTRODUCTION.

The brilliant generalizations of the historian Buckle touched almost every aspect of the department of knowledge in which he laboured and the people of well-nigh every land. An extremely suggestive view which he entertained concerning the backwardness of South Americans is full of interest to-day when this phase of our neighbour's civilization is of such wide current interest. He regarded South America as peculiar, in the sense that man was overburdened, one might almost say overawed, by Nature as upon no other continent. The tropical forests are too vast, in Buckle's view, the mountains and plateaus too high, the deserts too arid, for man's successful conquest.

The intimate student of South American problems at once frames a host of objections to this sweeping generalization, for, while it can not be gainsaid that the physical conditions of that continent are of fundamental importance in the development of its people and the

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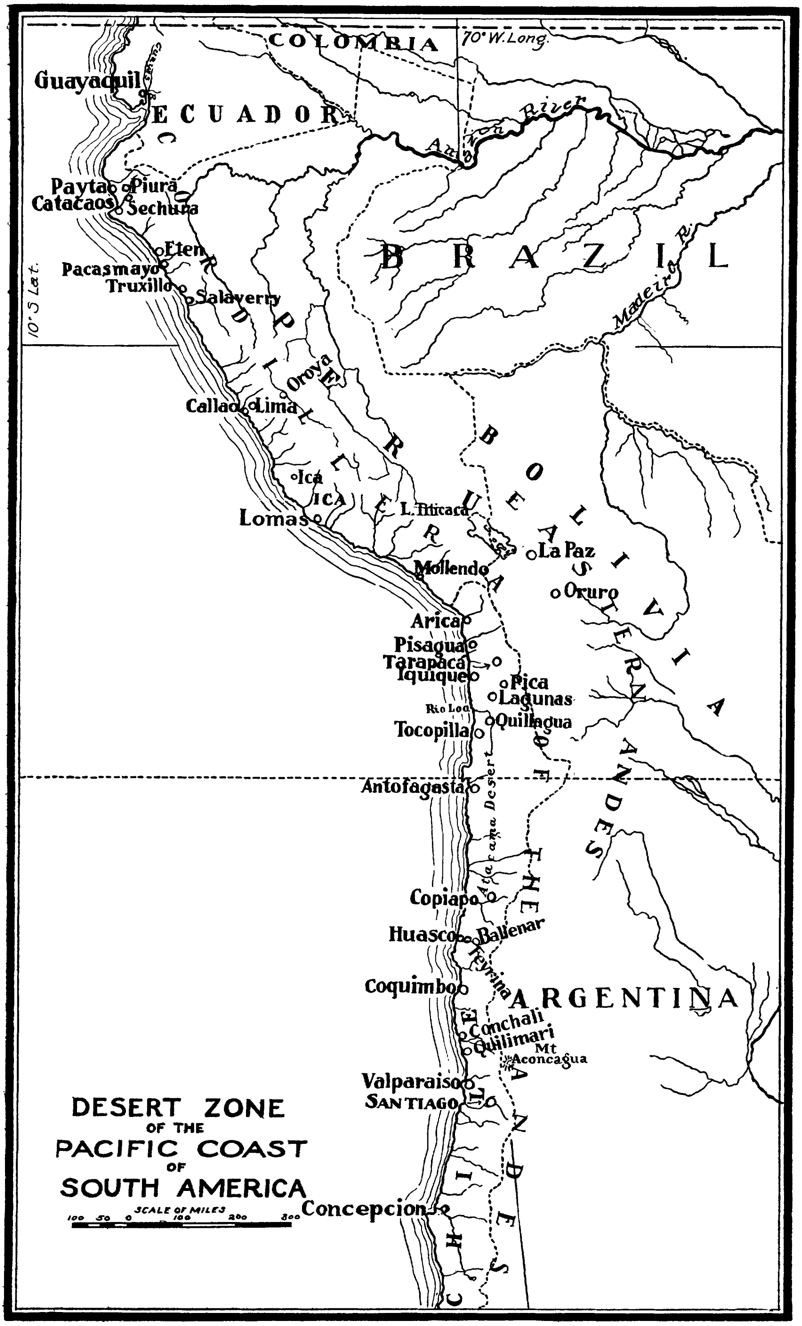
* There is no single name for the west coast desert of South America. Portions of it are called the Desert of Atacama, the Pampa de Tamarugal, the Desert of Tarapacá, Tablazo de Ica, etc. Some generic term is badly needed. The phrases "the west coast desert of South America" or "the desert of Chile and Peru" are highly unsatisfactory. The former is cumbersome, the latter includes with the coast deserts the mountain and plateau deserts which are of a totally different type. I propose that the most common term and the one which now includes the largest unit of this elongated desert be used to designate the whole. Few now use the word Atacama in the restricted and precise way in which it is used in Chile. A further slight extension of its meaning would supply the much-needed term. If at any time it is desired to use the word Atacama in its old restricted sense the phrase "The Desert of Atacama *in Chile*" might be taken as a reasonable substitute.



DESERT ZONE OF THE PACIFIC COAST OF SOUTH AMERICA natural resources of their lands, yet these have not been the sole determinants in holding that important part of the human race to the lesser achievements of the day. Something is due to the initial character of the Spanish conquerors and the spirit of the time in which they wrought; something also, to the torpid Indian character and the too large part of the total population he has constituted in some of the smaller countries; while many lesser and local causes explain the specific conditions prevalent in certain unhappy sections of that country to-day.

Yet, when the South American equation of condition is balanced, it is found true on the whole that physical environment constitutes one of the great factors in it, taking at least equal rank with the others; and that the environing forces of earth, air, and water have strongly and persistently moulded the will and the deeds of its people.

The President of the Royal Geographical Society,* in 1883, mentions Buckle's assertion only to suggest that later exploration might show it to be untrue. Already the impassable Andes of Buckle's day were being crossed, the illimitable Amazon forests were being penetrated and delimited and the stark deserts of the Pacific seaboard were being minutely explored for the wealth of nitrate they contained. It is customary to say that this is human conquest, that thereby man is bending Nature to his will, that he is annihilating what formerly overawed him. Such a view excludes the truth quite as effectually as the view it seeks to displace. For, even if railroads are run across the mountains, the desert reclaimed by scientific methods of irrigation, and rubber in enormous quantities gathered on all the highways and byways of a once impenetrable forest, all these are done by such methods and at such expense of human energy and capital, even of life, as to make them examples not of sheer human conquest, but of a conditional conquest. Nor can even these modifications be accepted as conquest performed by peoples who really inhabit the forests, mountains, and deserts. They are the performances, immediate or remote, of the sterner races, whose tastes have led them to the exploitation of many precious substances in lands that have long held the original races in a thralldom practically complete. The conquering influences are, therefore, of exterior derivation among peoples affected by difficulties like the indigenous peoples, but persisting in spite of them, because of the urgency of their needs.

No trade in the world, says Colonel Church, one of the authorities on South American geography, is carried on under such difficulties as those attending the production and transportation of the rubber of the Amazon basin. It has taxed the courage and endurance of the men engaged in it to an incredible extent:

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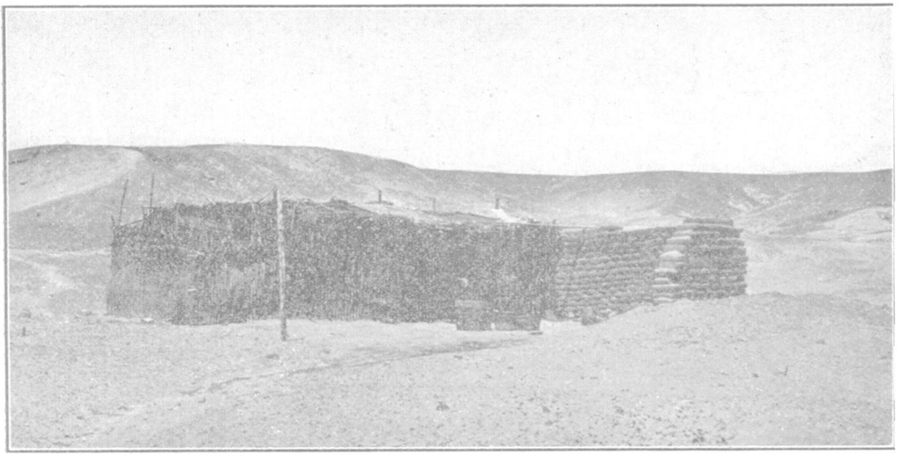
* Lord Aberdare in commenting on a paper by Markham on Explorations of the River Beni in 1880–1881, *Proc.* of the Royal Geog. Soc., Vol. 5, 1883, p. 347.

> It represents a continuous struggle under conditions which every year impose greater loss of health, life and material than an active military campaign, and the human suffering is appalling.]

This statement from a scholar, who knows the Amazon basin thoroughly through explorations extending over many years, is an emphatic corrective to any notion that defiance of the elements is the rule in South America to-day. Nature, it would appear, continues to stamp her character upon the achievements of men.

Therefore, to whatever extent Buckle's conclusion may be modified in its specific application, it forms on the whole a most suggestive view in the study of South American affairs, particularly in the case of the central Andes, where natural contrasts of hard conditions are not the exception, but the rule. Here the control of Nature over at east the indigenous population is in certain localities complete, and man is actually, as Buckle said, "overburdened" by the harsh environment in which he lives.



AN ISOLATED REED AND TURF HUT, SOUTH OF ETEN, PERU.

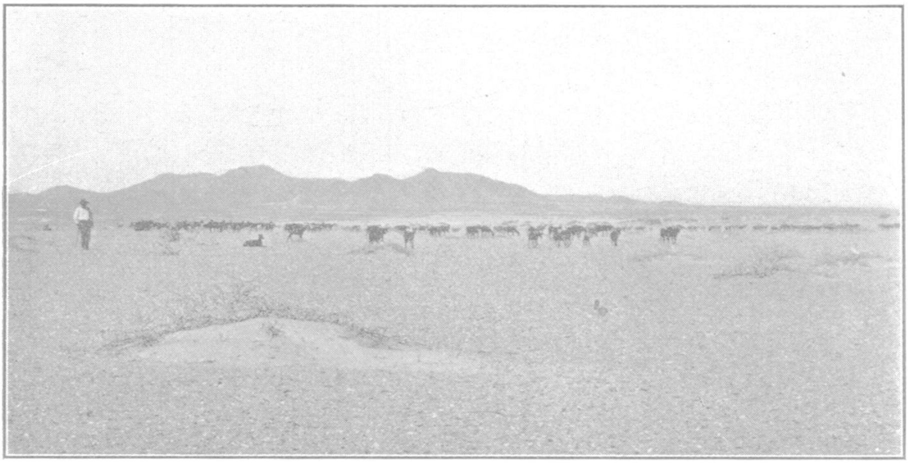
The owner gathers guano in the coast hills a half mile west of his home and sells it to the farmers in the irrigated Chancay Valley, a few miles inland. The light bamboo roof serves as an awning. It is built for shade and not for shedding water, for it never rains in this desert. The nearest approach to rain is the occasional heavy mist that collects mechanically upon the surface in sufficient quantities, in rare localities, to form a barely visible run-off.

The foregoing considerations of Man and Nature, and their interplay, will serve to introduce the complicated relations of the population units of the west coast desert of South America. These relations are not only of man to space and physical circumstance, but also those of man to time and of man to man. From the rude mud and reed shelter which some lonely dweller calls home it is a far cry to the well-built, well-stocked, electric-lighted and generally comfortable oficinas of the English on the nitrate pampas of Atacama and Tarapacá. The modifications worked by the superior race upon the inferior wherever there has been contact have been sudden and far-reaching; but out beyond their sphere of influence, in the isolated villages of the desert oases and lonely mountain valleys one could well and soon forget that such a people as the English ever commercialized the population groups near the sea. The unaffected groups still follow the old callings and ways of life and how far these are controlled by physical environment it is the chief purpose of the following pages to show.

PHYSIOGRAPHIC FEATURES OF THE DESERT OF ATACAMA.

The general physiographic description of the land forms of Atacama, their origin and stage of development, form the subject of a separate article. Therefore only those physiographic features are here discussed which exercise an unusual influence upon the population groups of Atacama. These features or factors are primarily climatic, at least in their immediate effect, and only ultimately topographic. For, while the topography of the Andes gives the climate its pronounced character, it is the climate and not the topography which is of immediate concern to the people. A second great physiographic factor and one whose operation is nowhere in the world more clearly illustrated than in that portion of the west coast desert east of Iquique, and known as Tarapacá, is the space relations of the water courses to each other, the sea, and the mountains; and hence the space relations of the population groups so intimately associated with them. These space relations, as will be seen in the closing paragraphs, at times overshadow every other factor, though they in turn rest back upon topography and climate as fundamental causes: topography, as intensifying the aridity and rendering it excessive as compared with most all of the other deserts of the world, as well as controlling the spacing of consequent streams; climate, as making agriculture, and indeed grazing, impossible beyond the influence of the life-giving streams and thus throwing the whole burden of subsistence upon the watered areas more or less isolated in horizontal space. Between the oases there is little to be gained and much to be lost in applying energy to the conquest of sheer space.

The west coast desert of South America is unique among the deserts of the world for its elongated quality. It stretches through 27 degrees of latitude, is over 1,600 miles long, and but 50 to 100 miles wide, a narrow strip of bleak, inhospitable, rainless coast. In journeying southward from Panama one discovers it with startling suddenness. At Guayaquil one sails through wide, green, river lanes, bordered with tropical verdure; and cattle graze on all the hills and grassy flood plain tracts within reach of the eye. A single night's journey to southward by steamer and one catches sight of the tawny foreland of Talara, with its city of petroleum derricks, and a few hours later anchor is dropped at Payta, the chief port of northwestern Peru. For the tropical foliage of the Guayas Valley at Guayaquil one has here only a few scattered drought-resisting bushes on a plain of yellow sand; for the great herds of cattle only meagre flocks of scrawny goats, and for the rivers and brooks of Ecuador only the dry water-courses of the well-nigh rainless coast desert of Peru.



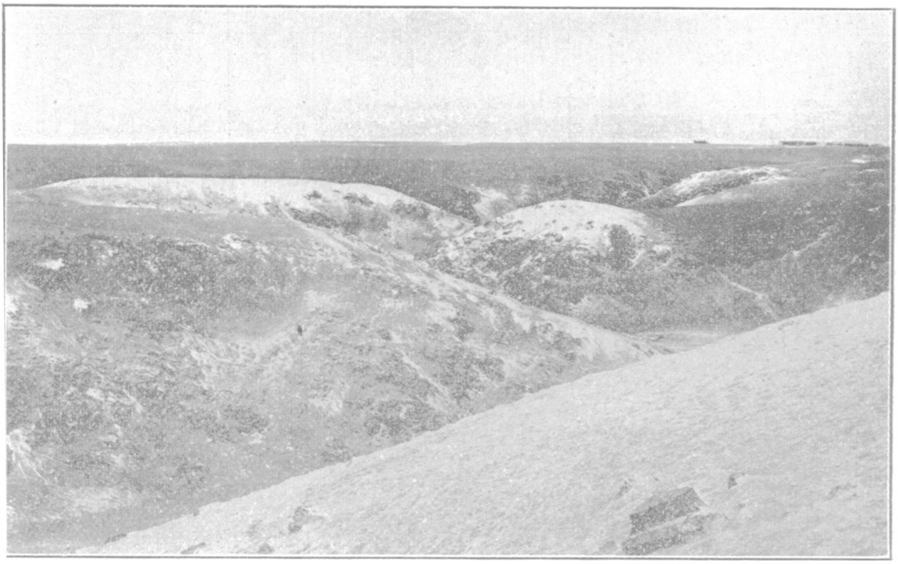
FLOCK OF GOATS AND SHEPHERD, EAST OF PAYTA, PERU.

The goats live upon short grasses, thinly scattered about during the wet season of approximately every seventh year. The rest of the time, as in the view, they range widely, feeding upon the freshly grown and more succulent parts of desert shrubs and bushes.

The precise degree of rainlessness which one may ascribe to this coast desert is a matter of some difficulty to determine. It is asserted by reliable residents that it rains but once in a ten- or twelve-year period, and that there is then no appreciable run-off.

In 1906 there was a three-days' "rain" at Iquique with a perceptible run-off. There were successive light showers with intervals of extremely heavy mist. On account of the heat the houses are built in very open style to permit free circulation of the air. Consequently, the rains and the mechanical collection of the penetrating mists mean the wholesale destruction of rugs, carpets, wall paper, and the like. It is impossible to keep out the moisture. The same disagreeable features are reported at Lima when the especially heavy mists of the winter season are driven in from sea.

Sievers* records the yearly rainfall average for Copiapó, Chile, toward the lower end of the desert, in latitude 27° S, as 10 millimetres, or less than a half inch. At Payta, Peru, it is said to rain on an average about once every seven years. Frequently the published accounts of these deserts ascribe to them a condition of utter rainlessness. Ball† compares the hard-featured landscape of Tocopilla to that which an observer might see upon the moon, and suggests that those who feel curious as to the moon's appearance will be gratified by a view of this scenery. The accompanying view represents borax drifts on the spurs of the gorges back of Mollendo, a substance so easily carried away by water as to make its presence in this form a safe indicator of a high degree of aridity. From an examination of the surface southeast of Arica there appears to have been no run-off due to local rain for hundreds if not thousands of years upon a tract



LOOKING SEAWARD DOWN ONE OF THE GORGES BACK OF MOLLENDO IN SOUTHERN PERU.

The white patches on the spurs entering the gorge are borax drifts blown from deposits of borax on the gorge floor further upstream.

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* "Süd- und Mittel-Amerika," p. 62.

† "Notes on a Tour around South America," *Geog. Journ.*, Vol. 4, pp. 624-626.

several hundred square miles in extent. There is a complete absence in this particular locality of the slightest sign of running water. Considering Newell's* statement that "even so small an amount of rain as 0. 1 inch will cause running water on lands denuded by excessive grazing" as authoritative and as applicable to these undissected surfaces, the exceptional aridity of this desert is at once apparent.

Even at Payta and Copiapó, at the extremities of the desert, the rainfall is exceptionally large and one must not take the rainfall conditions at these places as an indication of the general hyetal condition over the intervening 1,500 miles of desert. The infrequent rains of Payta, at the northern end of the desert, are clearly due to the occasional migration of the equatorial rainbelt to a more southerly position than usual. This brings Payta within the extreme margin of the rainy tract, while the rainfall of Copiapó, at the southern end of the desert, is due to a similar exceptional position of the northerly margin of the belt of westerlies in their annual northward summer migration. The marginal disturbances of this rainy belt produce a light and uncertain rainfall north as far as Copiapó, where the phenomenon of a rainy day has been well described by Treutler.† Between these two extremities the climatic conditions are under the absolute dominance of the southeast trades and the lofty Andine Cordillera. This portion of the desert is in the wind shadow of lofty plateaus and mountains. The moisture which the winds bear from the Atlantic is precipitated upon the coastal margins of the mountains and tablelands of Brazil or the eastern slopes of the Andes. The winds, therefore, have a drying effect and desiccate in proportion to the height of the barrier mountains from which they descend. Since the Andes are the loftiest and most continuous mountain belt of tropical lands, and by their northerly trend the more effectually shut off the rainfall of the easterly trades from the lands in their lee, it is easy to see that few, if any, of the tropical deserts of the world are so arid as that of the west coast of South America.

Up in the mountains the prevailing winds at night and during the forenoon are the trades and are in the southeast quadrant. Late in the afternoon a wind from the northwest springs up which is always cold and raw. On the pampa at Lagunas the wind conditions were in a general way similar. Between 1:00 and 3:00 P. M. a very sudden change occurs, the wind shifting to west or northwest, the indraught from the sea to the superheated land. At Santa Fé the change occurs at 3:00 P. M., but the wind almost invariably comes from the north and is called "the pampa wind." It is very hot in summer and is always accompanied by great clouds of dust whirled several thousand feet aloft, giving the air a yellow tinge. Frequently the view of the distant Andes is completely shut out. At Lagunas the west wind of summer afternoons blows almost directly from the sea and is cool, but by the time it reaches Santa Fé it has traversed 70 miles of desert and is very hot and disagreeable. These winds gradually diminish in strength after the first blow and die away late in the afternoon or at sunset.

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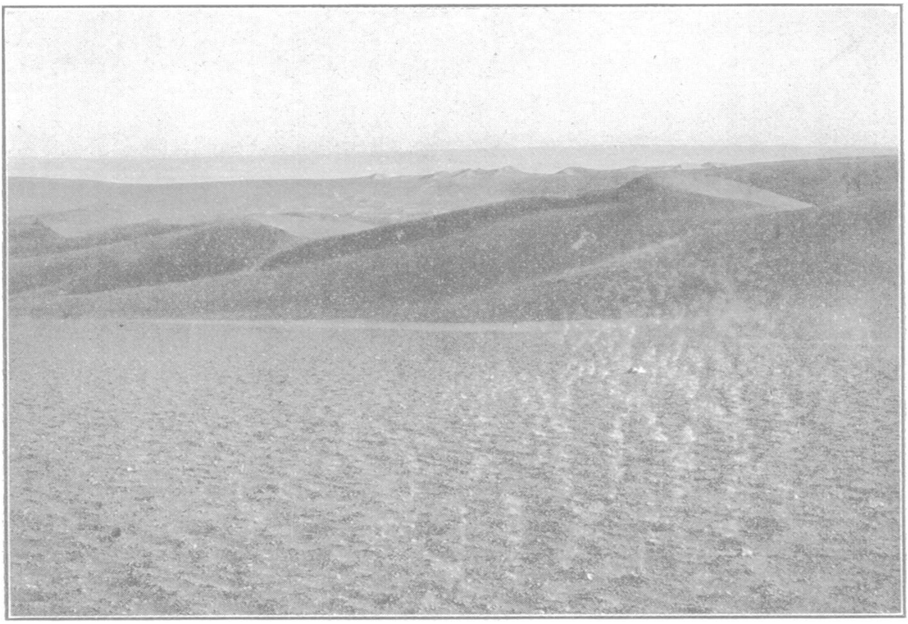
* "Irrigation in the United States," F. H. Newell, 1902, p. 45.

† Fünfzehn Jahre in Süd-Amerika. Part I, chap. xx, "Ein Regentag in Copiapó," pp. 135–136.

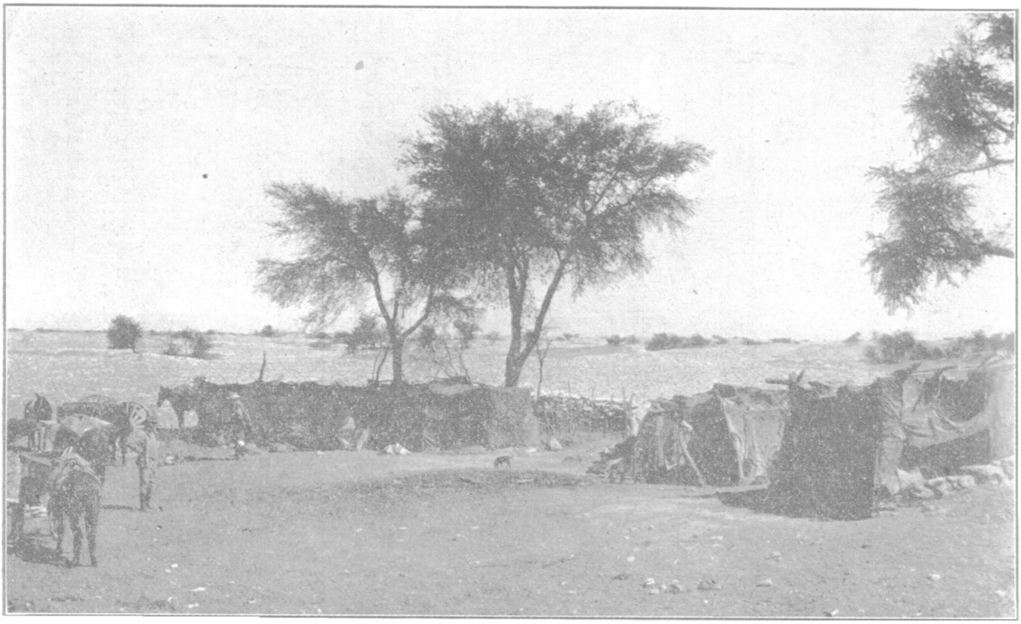


A GENERAL VIEW OVER THE DESERT OF TARAPACÁ, LOOKING NORTH FROM THE TRAIL EAST OF PICA, CHILE.

The sand dunes are marching east against the prevailing winds. This is due to greater strength of the ocean breeze of summer. It is this ocean breeze and not the gentler and more prevalent trade wind that does the most conspicuous wind work throughout the desert of Atacama. The lifelessness is absolute; not a single spear of grass or a single hardy shrub finds it possible to survive. For a good discussion of the difference in carrying power in winds of different velocities see an article, entitled "Relation of Wind to Topography of Coastal Drift Sand," by Pehr Olsson-Seffer, in the *Journal of Geology*, Sept.-Oct., 1908. Vol. 16, No. 6, pp. 549-564.

The dust-laden atmosphere results in wonderful sky effects, the marvel of desert scenery. The painted skies of dusk are the great reward of the desert traveler. The peculiar yellow light of sunset at first gives its colour to all objects on the pampa and the distant mountains. As the sun sinks lower, the effects become magical; the plain darkens; only the distant hills receive light of whose changing colours the pampa dweller never tires. The yellow becomes orange, then magenta, and, finally, purple, and, above all, the majestic snow-clad peaks glow in the fading light like great diamonds set upon the purple hills.

At higher elevations, along the arid flanks of the western Andes that constitute the eastern border of the desert, rainfall occurs in appreciable but unascertained quantities; and in the southern winter, snow occurs at intervals of a few weeks as far down as 11,000 or 12,000 feet. The rains on these western mountain flanks occur at lower elevations, at 8,500 feet and from 20 to 70 miles from the sea, where a thin sprinkling of vegetation is to be found, which increases with altitude to a notable degree. Even down on the nitrate pampa, scattered and extremely light showers are occasionally experienced on the higher portions. At 3,500 feet on the trail from central Lagunas to Pique we noted indubitable evidence of recent run-off in the form of freshly outlined but then dry rills and recent alluvial fans not yet sun-cracked or concealed by the shifting sand near by.



THE OASIS OF MONTE LA SOLIDAD (MOUNT OF SOLITUDE), 100 MILES SOUTHEAST OF IQUIQUE, CHILE.

There is no surface stream here for most of the year, but natural sub-irrigation supplies the various trees and shrubs that manage to survive. Drinking water is obtained from a ten-foot well that reaches the ground water. A single family of three lives here upon a few vegetables and the returns of the meagre flock of goats that feed upon the xerophilous shrubs scattered about. Cultivation was formerly far more extensive, as may readily be seen from the widely distributed marks of irrigation; but the population has been largely drawn off to the Lagunas nitrate works 25 miles to the north.

But such occurrences are to a high degree exceptional at this elevation.

In general, there is no vegetation whatever on the coast pampa except where the mountain streams come down or when, as in exceptional years, great areas are flooded by the swollen upland streams that then discharge their waters far and wide. From the oasis of Monte la Solidad, 25 miles below Central Lagunas, to the oasis of Quillagua, in the valley of the Loa, 50 miles to the south, there is not the slightest sign of grass or shrub—a truly lifeless desert. Except for the scattered oases there is thus a virtual absence of vegetation of any sort from the 8,500-foot level down to 1,500-2,000+ feet. At the latter height another belt of vegetation appears, owing to the cloud bank that almost perpetually hangs like a pall over the common edge of land and sea. It is often 5-10 miles wide and ranges in elevation from sea-level to over 2,000 feet. The natives speak of it as the poncho (cloak) of the sea, nightly drawn over its head. It is a persistent feature of the whole arid coast and is explained by the contact of the warm wind of the land with the unusually cold waters of the Humboldt Current that sweeps northward nearly to the equator.

It is a feature of great scenic interest, especially if one obtains, as from above it, a view of the dark islands and promontories of land projecting through the white sea of fog. So constant is the bank of cloud and so regular its position, that a thin belt of xerophilous shrubs occurs at this elevation and owes its existence to the mechanical collection of moisture upon the surface of the ground. The cloud particles adhere to the surface and to the plants, and are absorbed in some quantities by the earth, which is perceptibly moistened thereby. Evaporation from the ground is reduced not only by the shading effect of the cloud cover with respect to the sun's rays, but also by virtue of the high relative humidity its presence denotes. This feature was examined with much interest back of Mollendo, where numerous droves of donkeys and several herds of cattle were found subsisting upon the thin grasses and resinous shrubs whose range was clearly marked out on the mountainside. Above this level, as below it, is the naked desert. Darwin, on a trip across the coast ranges back of Iquique, notes the absolute lack of vegetation for 14 leagues except a few minute yellow lichens found growing upon the bleached bones of the mules' skeletons beside the trail.*

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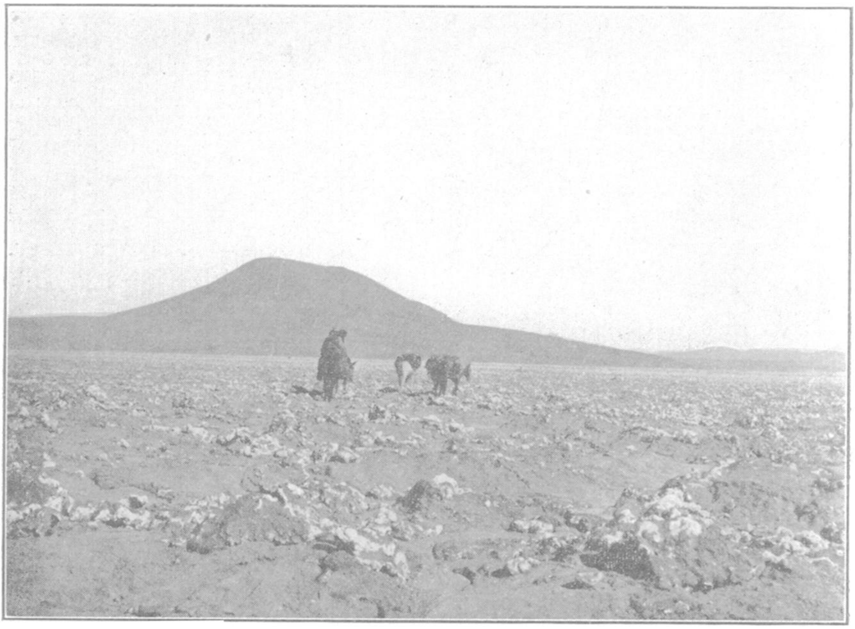
* "A Naturalist's Voyage, Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of H. M. S. *Beagle* Round the World," London, John Murray, ed. of 1890, p. 348.

The nitrate pampa of northern Chile (3,500+ft.) lies at the intermediate level between 2,000 and 8,000 ft., where lifelessness is the rule. Everything needed in the nitrate business must be imported.† There is no timber, no drinking water, no herbage for cattle, no wild animal life whatsoever. At Central Lagunas water is brought in pipe lines from Pique, 18 miles northeastward; fruit from the oases of Pica and Matilla, 55 miles in the same direction; and fish from the sea at Iquique, 90 miles by rail. Except for these three slender resources locally supplied, all the food and clothing, the building material, machinery, work animals, labourers, everything, must be drawn from more favoured lands. Here, as we shall see, is a condition common to many places along this naked coast and one which constitutes the most important geographic influence in shaping the political fortunes of the region.



CROSSING A SALAR IN THE DESERT OF TARAPACÁ, SOUTH OF MONTE LA SOLIDAD, CHILE.

These buckled surfaces are often of pure salt, whose glare tries the eyes of men and animals like snow. It is extremely rough and constitutes one of the most trying bits of the desert.

In contrast to these inhospitable conditions of the great intermediate areas of the coast desert are the more favourable conditions which obtain at the northern and southern extremities, where the transition is made to the belt of equatorial rains on the one hand and the belt of westerlies on the other. These border lands are often the most attractive fields of study by virtue of the more varied and mixed responses of their denser populations. Their chief features will be noted here by way of contrast to the special qualities of Tarapacá.

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† The nitrate industry and its geographical relationships is a subject too extensive and too involved with exterior forces to be an appropriate topic of discussion in connection with the population groups of Atacama. It will be treated in a later paper devoted exclusively to this interesting problem.

The three typical population groups of Atacama discussed in the following pages are not to be taken as the only types found there. There are at least two other types and a short series of sub-types. But the three chosen have a purer dependence upon natural conditions and are perhaps the most interesting of all. At least one other type is of great importance—the valley type of the coast of Peru, south of Payta, where extensively irrigated farms are cultivated and where the staple products are sugar, tobacco, cotton, rice, fruits, cattle, and the like. Both their interior and exterior relationships are, however, controlled to a notable degree by political, social, and commercial factors of a different order of importance than those here treated and hence will be described separately in a later paper.

(*To be continued.*)

GEOGRAPHICAL RECORD.

AMERICA.

THE SOCIETY'S COLLECTION OF FOREIGN GEOGRAPHICAL APPLIANCES USED IN SCHOOLS.—This collection of wall maps, atlases, and text-books used in the schools of some of the leading European countries has been on exhibition, with excellent educational results, for two months in the house of the Society. It will be seen during the spring and summer in some of the Universities of the middle West.

The collection has been loaned to the University of Wisconsin, where it will be exhibited at Madison from May 1st to June 15th. It will then be sent to the Ohio State University at Columbus, where the exhibition will open on June 21st and continue until July 10th. From there it will go to the University of Chicago, where the exhibits may be studied from July 16th till the middle of August. It is expected that lectures will be given on the collection at each of these institutions and that many teachers in Western schools will have ample opportunity to become familiar with the excellent features of these products while in attendance at the sessions of the summer schools held at the Universities. Arrangements for the exhibition of the material are being made at other educational centres in various parts of the country.

WATERWAYS TREATY BETWEEN THE UNITED STATES AND GREAT BRITAIN.—The treaty for the settlement of the waterways differences between the United States